PLANTERS' BULLETIN

OF THE RUBBER RESEARCH INSTITUTE OF MALAYA

PLANTERS' BULLETIN THIRTYSEVEN

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R R I

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EXPERIMENT STATION AND FACTORY. This station of the R R I is situated 16 miles from Kuala Lumpur, at Sungei Buloh on the Kuala Lumpur — Kepong — Kuala Selangor road. Visits may be made on Mondays or Wednesdays by arrangement. There is a guest house.

CORRESPONDENCE. All LETTERS must be addressed to the Director, Rubber Research Institute of Malaya, Post Office Box 150, Kuala Lumpur. Special inquiries may be marked for the attention of particular officers. The address for TELEGRAMS is Searching, Kuala Lumpur. TELEPHONE: Kuala Lumpur 72051. PARCELS occasionally arrive without any indication of their origin. Senders' names and addresses should be written clearly on the outside of all packages, and advice of despatch should be given by letter or telegram.

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Kuala Lumpur July 1958 Number 37

Editorial: Commercial Pesticides and the Planter

One of the functions of the R.R.I. is to screen commercially available products to find out which will be helpful to the rubber plantation industry, and to discourage the use of preparations which might be ineffective or harmful. It is necessary to distinguish between two types of material. Some are chemical compounds sold as such by suppliers, and not distinguished under trade names. Examples are copper sulphate, lime and sulphur dust — materials which do not lend themselves to incorporation into mixtures or to adulteration. Many others are substances offered to the industry in special formulations and sold under trade names, giving the manufacturer the opportunity of adding auxiliary substances the identity of which he need not disclose. Reputable manufacturers incorporate substances that improve the product. They are also careful to maintain the constancy of its composition, and to declare the concentration of the active ingredient, though there is in Malaya no legal obligation to do so.

Only in the case of fungicides for the treatment of mouldy rot is there an official testing scheme, introduced as long ago as 1931. Its aim was to ensure the satisfactory performance of the tar acid fungicides which, at that time, were the only materials used. They do not lend themselves to standardisation, though research work sponsored by the R.R.I. has given a good understanding of the fungicidal activity of the component fractions. The approval scheme has been maintained, with testing the responsibility of the R.R.I., and its usefulness has expanded somewhat in that the materials on the approved list are being recommended also in the control of other diseases. Any preparation submitted for approval as a mouldy rot fungicide must be examined. Even though the expenses of the test are recovered, we protect ourselves against waste of effort by requiring the composition to be disclosed, in confidence if need be. We also reserve the right to publish our findings.

How far should the resources of the R.R.I. be employed in testing new commercial preparations and in checking those already established? A comprehensive approval scheme would have to deal with all products, even those which are the same as others already on the market. It is beyond our means, both in staff and in money. All other testing of pesticides — fungicides, insecticides, rodenticides, herbicides — is therefore unofficial. We confine our attention to materials that we think might

benefit the industry, making no charge for such investigations. If the result is adverse, no report is made other than in confidence to the manufacturer or a prospective user. A favourable result appears as a recommendation in *Planters' Bulletin*.

Though we do not in general allow our recommendations to be used for advertising purposes, there is no objection to fungicides officially approved for mouldy rot control being advertised as having passed our tests. Agents who wish to quote us in their advertisements should have our prior agreement to the wording, as we do not wish to be represented as discriminating between equivalent products.

Wherever possible our recommendations for using a pesticide are expressed in terms of the active principle. Any supplier is free to put it on the market, stating the concentration on the package so that the correct dilution and rate of application can be followed. The attitude 'if a little is good, a lot is better' should be resisted. Too high a dosage may make the treatment uneconomic or damaging to the plants. The temptation to think 'if two things are good, a mixture of them will be better' can be just as wrong, for the two may neutralise each other. If some product still fails in its purpose when correctly applied, we would like to be informed so that the cause can be traced.

The procedure outlined, somewhat informal in certain respects, enables us to check on the standard of materials offered for sale to the planter.

Removal of Water from Coagulum in Sheet Manufacture

DURING THE PAST FEW YEARS THE R.R.I. has devoted considerable attention to the more fundamental aspects of the removal of water from rubber coagulum by the three mechanisms which occur in sheet manufacture namely machining, dripping and evaporation. Strictly speaking diluted latex serum is removed by machining and dripping, and water by evaporation, but in this article both are referred to as water. As the work has proceeded the results have formed the basis of our advice to estates and to engineers engaged in drying shed design, and to this extent our work has already found application in the practical field. The design of driers is receiving more and more attention in many sections of the industry as crops are increasing, firewood supplies are becoming less, and more expensive oil fuels are having to be used. We are therefore prompted to give an interim statement of our findings in the hope that it will enable factory managers to obtain maximum economy of running or maximum output from their existing driers, and also give to design engineers a more complete picture of some of the underlying principles than heretofore.

MACHINING

Latex is normally coagulated at 1.5 lb/gallon and there is thus at this stage 5.7 lb of water associated with each pound of rubber. Shortly after the latex is acidified a coagulum is formed which becomes progressively stronger as it is stored. When it has become sufficiently strong to handle and is ready for machining, the coagulum contains 3.5 to 5.0 lb water per lb of rubber. The water content is rapidly reduced as it passes through the rolls of the sheeting battery and normally the final sheet will have a water content of about 0.6 lb water per lb of rubber (or 60% water calculated on the dry rubber). This value is reduced somewhat if extra coagulating acid is used but the effect is relatively small; for example, if twice the normal amount of acid is used, the water content of the sheet will be about 40%. Apart from removing a lot of water, machining serves another useful function in thinning and increasing the area of the coagulum. The final sheet thickness greatly affects the subsequent drying operations, since the drying time is approximately proportional to the square of the thickness. A sheet which, for example, takes five days to dry needs to be reduced in thickness by only 12% in order to reduce the drying time to four days. The d.r.c. of coagulation, the partition plate spacing, and the intensity of machining all affect the thickness of the final sheet, and unsatisfactory smoke house operation can sometimes be traced back to these factors. Thick sheets can be produced by faulty dilution, bent or inaccurately located partition plates, or by worn bearings on the sheeting battery. For smooth smokehouse operation it is also important that all sheets should be of similar thickness since it is only when the thickest sheets are dry that a trolley load of rubber is ready to be removed from the drying shed. Some idea of the differences in drying time which can occur due to variations in d.r.c. and sheeting battery settings is given in the results of an experiment in which the d.r.c. of coagulation was reduced from 1½ lb/gal to 1 lb/gal. At the same setting of the sheeting battery the drying time was reduced from four to three days; when the battery was tightened down to give the same degree of compression with the thinner sheet the drying time was further reduced to two days.

DRIPPING

A machined sheet possesses the rather remarkable property of exuding water spontaneously even if placed under water or in a water saturated atmosphere. This process — known as syneresis — accounts for the rapid dripping which occurs during the first hour or so after machining. After about four hours at room temperature, syneresis is extremely slow and there is little point in leaving a sheet to drip for longer.

A sheet containing 60% water after machining will have a water content of about 40% after four hours. If, however, the temperature of the sheet is raised the rate of syneresis increases rapidly. This accounts for the renewed dripping when sheets which have virtually ceased to drip at

room temperature are placed in the drying shed. Syneresis plays an important role in the drying process right down to 15% water.

THEORETICAL ASPECTS OF THE MECHANISM OF DRYING

Some of the first systematic work on the drying of rubber was carried out in our laboratories some twenty years ago. Briefly, it was shown that the rate of drying is very rapid down to a water content of about 10%; thereafter the rate decreases abruptly, and further decreases as drying proceeds. The observation that the drying time from 10% water was roughly proportional to the square of the thickness of the sheet suggested that, during this stage, water was having to diffuse from the interior of the sheet to the surface. It was considered that relative humidity would have little effect on the rate of drying in the final stage. Recent work has, however, shown that there is a marked effect of humidity.

Our present views are that there are four stages in the removal of water from a sheet of rubber containing say 40% of water (that is one that has almost stopped dripping at room temperature).

1 As soon as the sheet temperature rises, when it is placed in the drier, the increased rate of syneresis exceeds the rate of evaporation and there is renewed dripping from the sheet.

2 The rate of syneresis decreases with time and, when it falls below the rate of evaporation, dripping ceases. The sheet surface is however still wet and evaporation can continue at a high rate.

3 At about 15% water syneresis ceases and the surface partially dries. We have a picture of water coming out from the interior of the sheet through a series of minute pores between the agglomerated rubber hydrocarbon particles. When syneresis ceases, the surface dries out except in those regions surrounding the ends of the pores. The rate of evaporation falls in proportion to the reduction of the wet area still exposed to the drying air. The area is reduced by as much as 12 times, causing a sudden drop in drying rate.

4 At about 10% water the ends of the pores dry out; thereafter diffusion through the pores is the only mechanism by which water can reach the surface and escape. It is this last stage which occupies the greater part of the drying time.

Against this background of the drying process we can now deal with the effects of the various drying conditions.

EFFECT OF AIR SPEED

Air speed has an important effect on the rate of drying down to 15% water. An air speed of 100 ft/minute gives an evaporation rate two to three times that obtained under natural convection conditions, assuming

that the relative humidities are similar. Above 100 ft/min the evaporation rate can be taken as proportional to the air speed raised to the power of 0.8.

Below a water content of 15% the drying rate is much less dependent on the air speed, the rate of diffusion of water from inside the sheet becoming more and more the controlling factor as the water content is reduced. In laboratory experiments in which we used air speeds as high as 600 ft/min no reduction in the time taken to dry a sheet down from 10% water was detected.

EFFECT OF TEMPERATURE AND HUMIDITY

When the surface of the sheet is wet, that is down to 15% water, the sheet will be at the wet bulb temperature of the surrounding air. The rate of evaporation is controlled by the rate at which heat can be transferred to the sheet to provide the latent heat of evaporation of the water. Heat transfer, and therefore evaporation, depends on the air speed, and on the temperature difference between the air and the sheet. At constant air speed the evaporation rate is therefore proportional to the difference between the wet and dry bulb temperatures of the air. Thus it is easy to calculate the combined effect of temperature and humidity, since wet and dry bulb temperature over a wide range are available in standard hygrometric tables. From the figures given in the Table it can be seen that raising the temperature from 110°F to 150°F at 50% relative humidity increases the evaporation rate by one third, while reducing the humidity from 75% to 25% relative humidity at 130°F quadruples the evaporation rate.

DIFFERENCE BETWEEN WET AND DRY BULB TEMPERATURE

Dry bulb temperature	*Relative humidity*		
°F	*25%*	*50%*	*75%*
110	—	18	8
130	37	21	9
150	43	24	10

Evaporation is not, however, the only mechanism of water loss. Particularly at high humidities, when sheet temperatures are relatively high, dripping will make a significant contribution. This reduces the variation in drying rate due to varying humidity because the reduced evaporation at high humidities is partially offset by increased syneresis and dripping.

From 15% water to 10% water is an intermediate stage in which temperature, humidity, and air speed all play a part. Many mechanisms operate in drying down to 10% water and they are not easily analysed quantatively but the overall effects are such that the drying time to 10%

water is about twelve hours in a smokehouse, about six hours in an air drying tunnel with forced circulation, and less than one hour under very favourable conditions of air speed and humidity in the laboratory.

More detailed information is available for drying below 10% water. *Figure 1* shows the effect of temperature on the time taken to dry a smooth sheet 3 mm thick from 10% to 0.4% water at 25% relative humidity. An increase of 10°F reduces the drying time by a quarter, or more, depending on the temperature. The black curve in *Figure 2* shows the course of the water loss from the sheet during drying at 140°F and 25% relative humidity. Approximately equal times are taken in drying from 10% to 4.5%, from 4.5% to 2.5%, from 2.5% to 1.2% and from 1.2% to 0.4% water. The sharply decreasing rate of drying makes it convenient to use a logarithmic scale for water content. The other curves in *Figure 2* show the marked effect of higher relative humidities. Raising the relative humidity from 25% to 55% increases the drying time by half. It will be seen that a sheet containing 0.4% water is assumed to be dry and this will be discussed later.

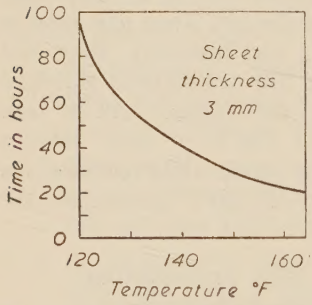

Figure 1. Effect of temperature on drying time from 10% water to 0.4% water at 25% relative humidity.

It is interesting to see how this increase in drying time with increasing humidity comes about. A piece of rubber which has been thoroughly dried at a given humidity will absorb water if it is exposed to a higher humidity; conversely it will lose water if exposed to a lower humidity. *Figure 3* shows how the change in weight of a piece of dry rubber hung in the normal atmosphere follows the changes in the relative humidity. The surface of a sheet dries out at a relatively early stage of the drying, as can clearly be seen if a sheet is cut to expose a section after one day in a smokehouse — the surface layer is translucent while the centre remains white and opaque. Thus the water content at the surface of the sheet will depend largely on the relative humidity of the air. The rate at which water diffuses out from the interior of a sheet depends on the difference between the water content in the centre and at the surface. Thus an increase in humidity increases the water content at the surface, reduces the difference in water content between the centre and the surface, and slows down the rate of diffusion.

MOULD GROWTH

The dependence of the water content of rubber on relative humidity also has a bearing on mould growth. The water content of a sheet at the time of packing will determine the relative humidity of the air spaces within a bale. Mould grows very readily at high humidity; even a well smoked sheet will develop mould after about four days in an atmosphere

of 96% relative humidity. Mould is unable to grow below about 75% relative humidity. The equilibrium moisture content corresponding to this humidity is about 0.6%, and thus this is the upper limit of water content which a sheet should have at the time of packing. Because the relative humidity of the atmosphere in Malaya is often above 75% sheets should be dried to a lower water content than 0.6% to allow for some reabsorption of moisture. In our drying experiments a value of 0.4% is taken as the end point, which is the water content in equilibrium with a relative humidity of 60%.

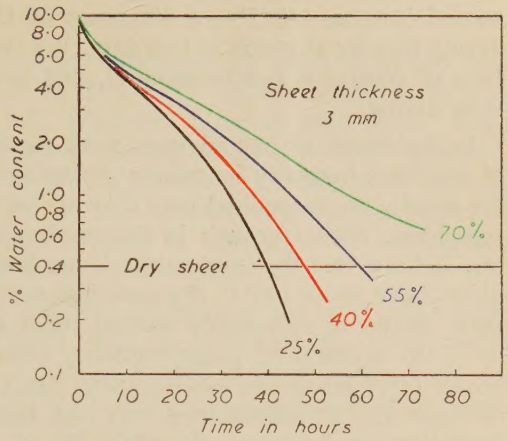

Figure 2. Effect of relative humidity on drying from 10% at 140°F.

When mould growth is causing trouble we recommend that the rubber is dried more thoroughly and packed as soon as possible, during the hottest part of the day when the humidity is low. Thorough drying can be achieved only with a relative humidity in the drying shed of less than 60% during the final stages.

SMOKEHOUSE PERFORMANCE

The major effects of temperature and humidity have a very direct bearing on smokehouse performance.

It is not easy to ensure accurate control of temperature in smokehouses and there is no doubt that many run below peak output because of irregular firing. Of the two temperature records illustrated overleaf, from the hot end of a smokehouse, the first was taken when the watchman was relatively untrained and left to his own devices. The second record was obtained after he had been instructed in the methods of temperature control and his performance checked every day. The average temperature in the first instance is 128°F and in the

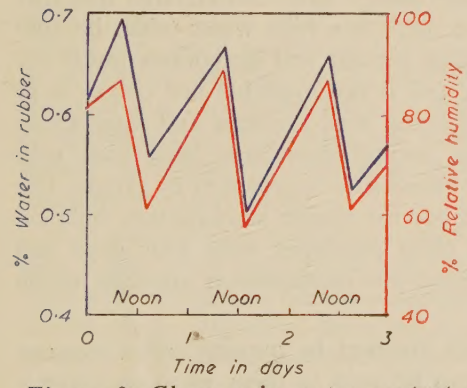

Figure 3. Changes in water content of rubber with changes in relative humidity.

second instance 143°F — a difference of 15°F — enough to change the drying time by as much as two days. We venture to suggest that the first type of control is not uncommon, and is the cause of many cases of slow drying.

In the course of our advisory work there have been clear indications of excessive humidity increasing drying time. High humidity conditions are usually not recognised until they are serious enough to show extreme symptoms. Mould growth in the smokehouse is a sure sign and may also indicate that the temperature is too low, for mould does not usually grow above about 120°F. If mould infection becomes serious, all affected parts should be thoroughly washed either with a 1% formalin solution or a 1% solution of paranitrophenol (*Planters' Bulletin 8*, page 107) before other corrective measures are taken. Condensation on walls and ceiling is also an indication of very high humidity although poor thermal insulation can accentuate the effect. As has been shown earlier, humidities not high enough to produce visible effects, yet higher than normal, can retard the drying appreciably. Diagnosing such cases is largely a matter of trial and error based on a knowledge of the factors involved.

CAUSES OF HIGH HUMIDITY

The three main causes of high humidity are: restricted ventilation; incorrect drainage of the smokehouse floor at the cold end and seepage into the furnace and flues. Ventilation in an R.R.I. tunnel smokehouse is adequate provided that the furnace side ports and roof ventilators are correctly adjusted. Poor drainage at the cold end of smokehouses is a common fault. As mentioned earlier (and in *Planters' Bulletin 21* page 104) a considerable amount of water drips from the sheet when it is put into the smokehouse even though dripping has virtually ceased at room temperature. In one instance where no drainage was provided and ventilation was poor, the sheet was still wet to the touch after drying for one day in the smokehouse. Some estates have considerable difficulty with smokehouse operation where there is a high water table, because water seeps in from the surrounding ground and evaporates inside the smokehouse. When an alternative site is not available one course is to construct a modified Subur smokehouse with furnaces and flues above floor level. Recently R.R.I. type smokehouses have been used with considerable success on artificially raised sites approached by ramps. The drying times recorded in one instance for similar smokehouses built on raised and on unraised sites in close proximity were four days and six days respectively. In neither case was condensation apparent inside the smokehouse.

We have emphasised the factors involved by quoting rather extreme examples so that due attention can be paid to them when choosing a factory site, specifying new smokehouses, and in supervising their construction and operation.

DRIERS FOR UNSMOKED SHEET

Driers in this category are used for producing air dried sheet and also the manufacture of smoked sheet by the partial smoking process (*Planters' Bulletin 35*, page 42). They fall into two main types: those constructed along the same lines as smokehouses, with roof ventilators and steam pipes for heating, and those with fans to circulate air through the drier, the air being heated by a heat exchanger placed in a recirculation duct. In the latter type, humidity is controlled by varying the amount of fresh air admitted to the recirculation duct.

Most of the remarks on smokehouse operation in the preceding section apply to this category of driers but there are certain special aspects which deserve mention. Since these driers are heated either by steam or by oil fired heat exchangers it is possible to control the temperature more easily than in a smokehouse, by the use of simple automatic controls. Thus a more reproducible output is obtained. In air recirculation driers the ventilation can be easily controlled, within limits, independently of the temperature.

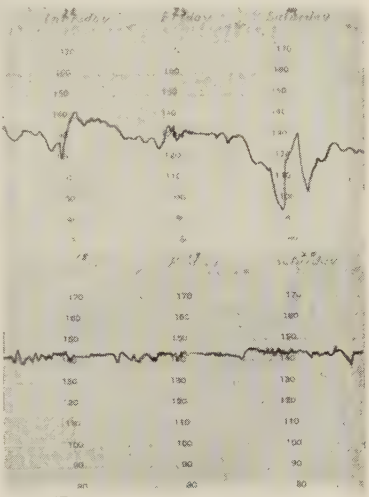

Figure 4. Smokehouse temperature records.
Above.....untrained operator.
Below.....trained operator.

OPTIMUM CONDITIONS

Because of these features there is more scope for trying out variations in operating procedure, to obtain the maximum output or maximum economy of running. These two objectives are to some extent opposed for a particular drier. At a given temperature, if no recirculation is used, the low humidity gives rapid drying but the fuel bill is high. At the other extreme, if only a very small amount of fresh air is introduced, the fuel bill is low but the drying is very slow. There is thus an optimum condition which lies somewhere between the two. A preliminary assessment of our data suggests that the optimum relative humidity is about 25%.

It is not possible to maintain such a low humidity during the first part of the drying cycle unless very large heaters and fans are employed. Thus high humidity is usually accepted during this stage with consequent loss of output. However, there are certain compensations. Syneresis will be more rapid at the higher humidities and will partially offset the lower rate of evaporation from the freshly loaded rubber. Also, our experiments have shown that the use of very high humidities in the early stages reduces the tendency for blister formation thus permitting the use of

higher temperatures. This is of importance in well insulated driers in which the temperature drop between the hot and cool ends is small.

The higher the drying temperature that can be used, the more economic the drying will be provided that uncontrolled leakage of air is kept to a minimum. The limiting factor is blister formation, which appears to vary with the source of latex and the method of preparing the sheet. We have even dried sheets at 160°F without blistering. It is therefore likely that some factories could use higher temperatures than the usually accepted maximum of 140°F. In large installations where several driers are employed it may be advantageous to dry to 10% water in one drier and to transfer the rubber to another drier for the remaining stage. The disadvantage of having periods of high humidity at intervals throughout the drying cycle is then avoided.

CONCLUSION

From the foregoing it will be seen that differences in drying rates can arise from many causes, all of which have to be considered if smooth drier operation is to be obtained.

The most economic methods of drying have yet to be determined and there are still many gaps in the knowledge available. Our contribution to this field in recent years has been to obtain fundamental data on which new developments can be based, and which provide a sounder basis for our advice on new driers and the rectification of faults in existing ones.

In this article an attempt has been made to bring together as many of the relevant facts as possible and to indicate where they have direct practical application.

Dusting Machinery for Estate Use

AS A SIMPLE AND RELATIVELY CHEAP METHOD of applying fungicides and insecticides to hevea, or to the cover crops grown with it, dusting has much to commend it. It is low volume spraying carried to the logical extreme, in which the diluent liquid is dispensed with altogether, and the particles are tiny solid fragments of the active agent. An inert substance such as kaolin is used for the dilution necessary to prevent clumping. The active agent may be diluted 1 in 20. Thus the wasteful transport of diluent is very much reduced as compared with high volume spraying, where the weight of diluted pesticide may be one hundred times that of the equivalent quantity of active agent made up as a dust. It is in the greater power of sticking and more accurate distribution that spraying is so often preferable to dusting, and this article should not be taken to imply that dusting is as efficient as spraying. Dusting is less efficient in general and it is intended merely to describe applicators for use when dusting is recommended.

Figure 1. A small duster held and operated by one hand, applying DDT dust to the leaves of nursery plants. The bellows expand and contract as the wrist is flexed.

Although there is less diluent to be transported on the estate than with spraying it must be remembered that the active principle has to be mixed with the diluent by the manufacturer and imported with it. With spraying, the diluent is water and diluting costs no more than the negligible labour costs, even if there is more of the made-up pesticide to be carried round the field.

HAND DUSTERS

The applicator for a dust is normally simpler than a sprayer designed to do a similar job, and has fewer parts to go wrong; as there are no high pressures to be resisted, it can be made of very light materials. Simplest of all is a bag of coarse cloth containing the dust carried along the rows of plants, and beaten with a stout stick. Such a method is not to be despised for use on a small scale, even in these days of mechanisation, as the resulting dust is fine and well-distributed. As effective, and

Figure 2. Dusting a field budding affected with powdery mildew. The air jet from the piston pump forces dust out of the container near the outlet.

Figure 3. Dusting cover crops with a rotary duster of a type that is popular on estates. The handle in the right hand is geared to the rotating brushes; the left hand steadies the machine.

more comfortable for the operator, is a leather bellows from which the dust can be pumped and directed through a short nozzle. The bellows operated by one hand (*Figure 1*) are convenient for treating a small number of plants. Somewhat similar is the rubber bulb with a fine brass nozzle, used for blowing white arsenic into the earth-covered trails of termites on a mature tree, when the usual aldrin treatment has failed to eradicate the pest.

A hand duster which dispenses with bellows is constructed with a piston pump similar to a sprayer (*Figure 2*). The barrel and plunger are of greater diameter than those of a sprayer, so that a large volume of air is moved at each stroke. The outlet orifice is small and the inlet fitted with a valve to prevent dust being sucked back. As with the hand sprayers, an improvement is to arrange for a constant stream of dust despite the uneven pumping. Such a machine is much less tiring to use than bellows as it is so much better balanced.

Figure 4. Using a diaphragm operated knapsack machine for dusting cover crops. The right hand works the operating lever while the left hand directs the stream of dust.

DUSTERS SUPPORTED BY THE SHOULDERS

The manually operated duster most used for agricultural work is hung on the shoulders, resting either on the back, as a knapsack, or on the chest. A greater load of dust can be carried on the back, but a more complicated mechanism is required to work it and to bring the dust to the front of the operator. The simplest machine consists of bellows suspended in front of the operator, with handles by which the air within is forced out, carrying dust with it through a tube projecting to the front.

An improvement on the above type is the chest-mounted rotary duster (*Figure 3*), the most popular model for estate use. It has a small hopper from which a continuous stream of dust can be emitted by turning a handle placed in the natural position for the operator's hand and geared up to a rotary fan. The handle also works rotating brushes that force the dust through an adjustable feed mechanism, usually consisting of a plate sliding across a slot, and a short tube carries the dust to the front.

Figure 5. Dusting covers with a power operated machine slung from the operator's shoulders. The dust feed is turned by the operator's left hand. Wide flexible tubes carry the air stream.

The knapsack bellows duster (*Figure 4*) consists of a rigid container bearing a lever working a large leather diaphragm, to give the bellows action. An agitator is joined to the operating lever. The result is not very satisfactory, for the leather washers readily deteriorate under tropical conditions, and the dust cloud is intermittent.

A knapsack model can be combined with a rotary fan, but with a large hopper placed on the operator's back, combining the efficiency of the rotary fan with the greater load of the knapsack.

Except for recently introduced mist-blowers, which work with an exceptionally low volume of liquid, the weight of spray fluid prohibits the addition of an engine to the operator's load. With dusters, the weight of the pesticide is so little that an engine can be incorporated into the mechanism of a shoulder-slung duster without overburdening the operator. A model of this type, with a miniature two-stroke engine mounted on the operator's chest and the hopper on his back, is illustrated in *Figure 5*.

This model is not fully mechanised in that the feed brush has to be manually operated to deliver the dust into the suction tube, to be carried in the air stream to a wide, flexible, outlet pipe. Small machines of this sort are liable to give trouble in the hands of inexperienced operators.

LARGE DUSTERS

For treating ground crops it is usual in other branches of agriculture to employ traction dusters operated by direct coupling to the rotating wheels, but they have no place on rubber estates. Shoulder-mounted machines are most suitable for treating covers on the rough and often steep ground. Power dusters used for treating the hevea trees themselves have to be among the most powerful made; few other agricultural uses call for a machine that can send a dust cloud 60 to 70 feet into the air.

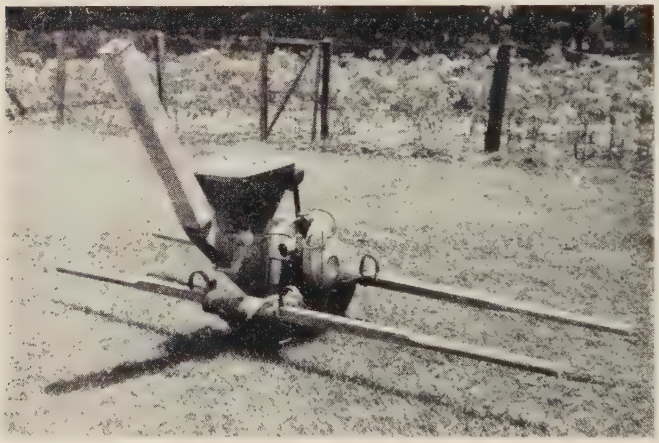

Figure 6. A power operated duster for treating mature trees, shown fitted with carrying poles. The dust placed in the hopper on top of the machine, is ejected through the square pipe to the left.

These machines have been used extensively in Ceylon for the control of *Oidium heveae*. In Malaya they are used commercially only in dusting seed gardens. The most useful sort can be carried in a small truck or man-handled over rough ground. A model that has given good service on our Experiment Station is shown in *Figure 6*. It has been used experimentally to apply ferbam, ziram, and BHC formulations, as well as sulphur. The dust must be well dried and ground before starting, not only with this machine but with all dusters. Under conditions prevailing at the Experiment Station it has been found best to have a team of three pairs of labourers under a field assistant. The members of a pair should be of equal height. The machine is taken by truck as near as possible to the site, the two-stroke engine charged with the correct petrol/oil mixture, and then the carrying poles are fitted. The field assistant acts as mechanic in charge, carrying the starting cord, plug spanner, spare plug and cloth. Two pairs of labourers manoeuvre the machine while another pair carry the dust. The pairs change places every twenty minutes to relieve those carrying the machine. The best conditions have been found

to be from 7 a.m. to 9.30 a.m. when there is dew on the leaves and the air currents are gentle. Later than this wind may blow the dust away from the trees, and there is no film of moisture to retain the dust.

The diffuseness of dusts as compared with sprays means that the labourers must be protected by wearing shirts, hats, and goggles, even when dusting with sulphur. Other dusts than sulphur should not be used without taking their toxicity into account.

Control of Pink Disease

A DESCRIPTION OF PINK DISEASE SYMPTOMS has been given in the article on page 50 of *Planters' Bulletin 18*. In the three years that have elapsed since this article was published we have gained more information on the circumstances under which pink disease is likely to become a problem, and the best methods of treating it.

PREDISPOSING CONDITIONS

The importance of clonal susceptibility has been demonstrated repeatedly from estate records and from a census on our Experiment Station. These record the highest susceptibility in RRIM 501, and the next highest in RRIM 618 (which is not now recommended for planting, on other grounds). Tjir 1 has been demonstrated to be more susceptible than other clones, although less so than RRIM 501. In one experiment, six-year-old RRIM 501 had 189 cases per thousand trees, while Tjir 1 had 51 and PB 86 only 4 per thousand.

The seasonal nature of the disease is very apparent, indicating that treatments need not be continued the whole year round. In Selangor, October/November and April/May can be considered the pink disease seasons; elsewhere the wet seasons fall in other months.

The other important factor is soil; the figures quoted in the note on page 62 of *Planters' Bulletin 30* show a remarkable degree of freedom from disease on coastal alluvial soil types. Some inland soils, for example the Tampin series, also appear to be free; but this has not been confirmed. It is tempting to conclude that it should be possible to control the disease by manuring. This is being investigated, but no recommendations can yet be made. As even susceptible clones are immune on coastal soils, there is no need to take pink disease control into account when planting on these soils. It must be emphasised that, even when a susceptible clone is growing on an inland soil known to be favourable for pink disease, effective control can be obtained without great trouble or expense.

TREATMENT

It has become clear that the disease can be treated entirely from the ground, without recourse to climbing the trees to prune branches or

Treating pink disease by directing a stream of fungicide, from a stirrup pump, through a 10 ft lance. The fine jet, which can just be seen in the picture, reaches to the branch at the top right.

apply a fungicide. It is necessary to use a high pressure sprayer connected to a long lance fitted with a nozzle that gives a fine jet. With this arrangement, branches up to thirty feet from the ground can be sprayed. Infected branches above this height can be ignored; they may recover, and if they are lost not much harm is done. If the infection extends down the tree within range of the sprayer, it can be treated at the time of the next round. Knapsack sprayers can reach the requisite height, as can stirrup pumps, which have the additional advantages of robustness and the ease with which the buckets can be refilled. On our Experiment Station we have tested several different models, both hand-and power-operated, of the type of sprayer that draws its liquid supply from a bucket on the ground. Stirrup pumps have proved the simplest to maintain and transport. The nozzle can be fitted directly to the end of the delivery tube, the last few feet of which are lashed to a light bamboo pole, or it can be fitted to the end of a bamboo lance fed from the delivery tube. The spray discharge of the stirrup pump nozzle usually supplied has insufficient range to reach the higher branches and wastes much liquid because of the diffuseness of the spray. A straight jet is obtained by fitting a nozzle holding a steel or porcelain disc with a hole in the centre. A diameter of 3/64 inches gives about the right rate of delivery.

The fungicides advised for treating pink disease are Bordeaux mixture or a proprietary copper fungicide, Fylomac 90 at a concentration of 0.5% (8 ounces in 10 gallons) or one of the tar acid fungicides recommended for treating mouldy rot, used at the higher of the two concentrations given on page 69 of *Planters' Bulletin 25*. A copper fungicide can be used only before the trees are brought into tapping, because of the danger of contaminating the latex, with consequent deterioration of the rubber. Fylomac 90 and the tar acid fungicides can be used whether or not the trees are in tapping, but care should be taken not to wet the leaves,which are scorched by these materials. A dye incorporated in Fylomac 90 and in some of the others makes it easy to see where treatment has been applied.

Whatever material is being used it should be passed through a fine mesh sieve (forty wires per inch) to exclude any dirt which might clog the nozzle.It is convenient to have a sieve that rests on the sides of the bucket. The ordinary straight sided latex bucket is an ideal container from which to draw the spray liquid. When using copper fungicides, which corrode galvanised iron, the buckets should be protected with two or three coats of cellulose paint, and the sieve should be of Monel mesh.

BORDEAUX MIXTURE

Bordeaux mixture, which is both cheap and effective, must be most carefully prepared. It is convenient to make up the mixture in the field, when the procedure should be as follows. The quantity to be made up at one time should be decided upon and the appropriate weights of finely powdered copper sulphate and of lime parcelled up. Assuming 40 gallons to be made, one parcel will contain 4 pounds of copper sulphate, the other 5 pounds of quick lime or $7\frac{1}{2}$ pounds of slaked lime. In the field a container of any material other than unpainted iron or galvanised iron is filled through a strainer with 40 gallons of water. The lime is placed in one of the sprayer buckets and successive small quantities of water, taken from the 40 gallons, added to it until it crumbles to a powder, then more water is added until the bucket is full of a milky suspension. The powdered copper sulphate is washed through a sieve directly into the remainder of the 40 gallons in the container; then, when it has all dissolved, the bucket full of lime suspension is poured through the same sieve, stirring all the while with a wooden paddle.

Small quantities of mixture can, of course, be made up if proportionately smaller weights of the two ingredients are taken to the field. On some estates the large container is dispensed with altogether, mixing being done in the spray buckets.

If badly prepared, Bordeaux mixture will clog the nozzle of the sprayer and will fail to stick to the branches satisfactorily. The quicklime used should be sealed off from air and moisture by the supplier within a day or so of burning, and stored in sealed containers to prevent it absorbing moisture and carbon dioxide from the air, as it readily

does. If the lumps fail to break down with the evolution of heat when water is added, the lime is unsuitable for use. Imported hydrated lime packed in multiwall paper bags deteriorates less quickly, particularly if the bag is resealed whenever some of it is removed. Although dry to the touch, hydrated lime already contains one third its weight of water, which accounts for the instruction to use half as much again as one would use of quicklime; it does not heat when wetted.

The proprietary copper fungicides, based on copper oxide or oxychloride, are powders that readily disperse in water. The tar acid fungicides are either emulsions already or they emulsify spontaneously in water. Fylomac 90, which is water soluble, is best left overnight to dissolve, as it does so rather slowly.

Cover Plants—A Discussion

A GENERALLY ACCEPTED POLICY IN present day rubber cultivation is to grow indigenous or introduced plant species as a protective ground cover between the rows of rubber trees. The need for an effective ground cover is particularly urgent during the early stages of growth of the rubber, before the trees have developed a closed overhead canopy that can offer some protection to the soil. Even after the canopy has closed over there is still need for a ground cover, for the protection offered by the trees is not sufficient to prevent soil erosion.

THREE VIEWPOINTS

With costs at their present high levels there is much discussion among planters concerning cover plant policies in young plantings. Some argue that it is not economic to plant special covers, and that all expenditure should be concentrated on the rubber trees, allowing grasses and other indigenous growths to develop, with the minimum of attention, in the inter-row areas. Other planters argue that the considerable effort needed to establish leguminous creepers is justified; they affirm that the cost of this operation is more than repaid by enhanced tree vigour resulting from the improved soil conditions. Others, again, sympathise with this view but point out that leguminous creepers are not permanent covers and are generally replaced by grasses after a few years; they suggest that the legumes may not be able to develop their optimum effects in their one or two years of vigour, and so may fail to justify the cost of their establishment.

IDEAL COVER

Let us consider what is required. The ideal cover plant would be one that could be established quickly to cover the ground in either a jungle planting or in a replanting. It should have sufficient leaf to shade the ground completely, grow thickly at ground level and produce sufficient

mulch to prevent soil wash. In addition it should add large amounts of organic matter to the soil, thereby improving its physical condition; as a consequence the soil will become more permeable, retain moisture and nutrients better, and conditions will be more conducive to the development of an active microbial population. The ideal cover should consist of an association of plants that will grow in the open and cover the ground when rubber trees are small, yet persist under shade after the tree canopy has closed over. The plant association should have a range of rooting depths such as to maintain a stable nutrient cycle in the soil, and yet this rooting should not be so strong as to compete severely with the rubber roots for available soil moisture and nutrients.

The requirements for our ideal cover appear to be highly exacting, yet they are almost completely met in a vigorous mixed cover of class A and class B indigenous growths described by W.B. Haines in 'The Uses and Control of Natural Undergrowth on Rubber Estates'. A mixture of various figs, ferns, mahang, coffee, ginger and creepers provides a very good soil cover which should be sought for in all plantings where conditions are suitable. Such plantings are those from virgin jungle, and replantings where vigorous natural covers existed under the old rubber.

DIFFICULTY OF ESTABLISHMENT

Unfortunately the mixed cover of indigenous plants departs from ideality in that it cannot be established quickly, nor possibly even economically, in plantings on old lalang or belukar land or in replantings where the soil is bare or thinly covered with grasses and perhaps by a few undesirable plants such as Straits rhododendron. These latter areas provide the great bulk of present day plantings and the planter, faced with the practical impossibility of getting a suitable indigenous cover, must decide whether to plant legume creepers or to minimise expenditure and allow any plants to develop in the inter-row areas, concentrating his attention on the rubber. If he takes the latter course it is most probable that he will soon have a complete grass cover or, in the more moist areas, a cover of the creeper *Mikania scandens*. Both meet some of the requirements of our ideal cover plant: they will check erosion effectively, and keep the soil surface cool. However, neither plant adds any appreciable amount of organic matter to the soil and they contribute little towards improving soil fertility. The *Mikania* will be superseded by grass as the rubber tree shade develops, and the strong surface rooting of the grasses generally found in rubber areas offers serious competition with the rubber for available soil moisture and nutrients.

It is sometimes suggested that the effect of competition can be compensated for by applying extra fertilisers along the planting rows. The addition of more fertilisers will not, however, necessarily make up for what is lost by failing to establish a cover that not only protects the soil from degradation but also helps to build up its fertility. Extra fertilising will be effective only if nutrient deficiency is the limiting factor.

but if tree growth is restricted because of poor soil aeration or lack of moisture, the addition of more fertilisers will have no beneficial effect.

RESTORING IMPOVERISHED SOIL

An important point with respect to replantings is that the soil under the old rubber, which in all probability was at one time subjected to clean weeding, will be at a considerably lower level of fertility than when it was first planted up from jungle some thirty to forty years ago. The replanted trees cannot be expected to grow as well as those of the first planting, even with the application of fertilisers, unless steps are taken to restore some of the lost fertility by establishing cover plants which will add large amounts of organic matter to the soil. The early years of immaturity of the rubber, during which time the cover plants receive almost full light and are therefore growing vigorously, present the only practicable opportunity when this can be carried out. When it is considered that the replanted rubber will occupy the ground for another thirty or more years, the importance of improving soil fertility as much as possible in the few years available can be appreciated.

The most effective way of improving the soil is by establishing a vigorous cover of the leguminous creepers *Calopogonium mucunoides*, *Centrosema pubescens* and *Pueraria phaseoloides*, alone or associated with leguminous and other bushes. In nine months from planting, these creepers can be expected to cover the inter-row areas completely; from then on a steady accumulation of dead leaf material builds up under them. This litter mulch conserves soil moisture; its decomposition releases nutrients to the surface feeding rubber roots and organic breakdown products that help to improve soil physical conditions. As the tree shade develops, the leguminous creepers die out, but the organic mulch left behind can be expected to exert a marked beneficial effect on soil nutrient and physical status for some years more. The better types of upright indigenous plants growing with the leguminous creepers should not be eliminated but encouraged, to provide a cover that will persist under the mature rubber after the legumes have died out.

NITROGEN FIXATION BY LEGUMES

Purely on a comparison of the amount of organic matter produced the leguminous creepers prove superior to grasses and to *Mikania*. In addition, the nodules on the roots of the legumes fix atmospheric nitrogen. In a recent pot experiment *Centrosema pubescens* fixed nitrogen equivalent to 10 cwt/acre of ammonium sulphate in a period of five months from sowing. This large figure receives confirmation from observations in the field, and shows that even when legumes persist for only a short time they will add an appreciable amount of nitrogen to the soil. Much of this nitrogen is held in organic form in the litter and is slowly made available to the rubber tree by decomposition processes.

The above arguments in favour of leguminous creeping covers are based largely on theoretical considerations that are now under test in an extensive programme of field experiments. Supposing that experimental results fully confirm our reasoning, the planter will still be faced with the problem of deciding which type of cover is cheapest in the long run. In a future article we shall approach the problem with a discussion of the most economic methods of establishing and maintaining legume creepers.

Correspondence

The Editor invites letters of general interest for publication in this column. Comment and queries arising from articles recently published will be welcome.

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PLANTING DENSITY

The article 'Achieving an Optimum Stand' in your issue No. 34 of January 1958 advocates a selective thinning programme to obtain tapping stands of 100 or 120 trees per acre according to the material employed. Selection on yield in the early years of tapping clonal seedlings is explicity advised, and you remark that the excess of 50% at planting over the desired tapping stand for budgrafts should be adequate to leave a margin for selective thinning on yield and secondary characters when the trees are in tapping. But the importance of this point, especially for modern high yielding clones, is not adequately stressed. Indeed it is possible to gain the impression that a stand at opening of only 100 trees per acre would be acceptable for a high yielding clone.

If the trees were thinned during immaturity to such an unconventionally low stand, they would probably be opened earlier, but the yield per acre would be lower. Experience shows that rather higher stands can be tolerated during the first years of tapping without serious detriment to girth increment or bark renewal. However, more important than the loss of crop would be the lack of scope to remove trees which proved defective in tapping.

The employment of higher densities at planting would permit drastic thinning of all rogues, runts, diseased and damaged trees during early immaturity. These thinned points would not need to be supplied owing to the high initial stand.

The density problem involves balancing conflicting trends: yield per tapper versus yield per acre; age at opening versus yield at opening; early yield per acre versus later development and performance. Your article tends, perhaps, to give undue weight to the advantages of low stands, whereas the disadvantages should be considered too.

Eaglehurst Estate
T.M. Tobin, A.I.S.P.
Manager

We thank Mr Tobin for emphasising the importance of selective thinning during the first years of tapping of budgrafts. Our recommendations allow for and urge this practice, although the point is rather lost among others discussed in the article to which he refers and we are glad to take this opportunity to clarify any misunderstanding.

Of the trees planted surplus to the 'final' tapping stand, we envisage the removal of up to two thirds during immaturity and the remainder during the early years of tapping. This includes involuntary losses due to disease. For example:

	Budgrafts		*Seedlings*
Initial density	*150*	*180*	*240*
Stand at opening	*117*	*140*	*140*
Final tapping stand	*100*	*120*	*120*

We agree that the development of the trees will not suffer unduly at the stands suggested for opening, but there comes a time when we must consider the 'early years' over. Thinning to the final stand should be completed, we suggest, by the end of the third year of tapping.

The surplus at planting can be increased to allow more drastic thinning during immaturity, if the cost of the material discarded will not be grudged and the necessary supervision can be given. Excess trees should not be retained too long into the period of closed canopy and tapping, or there will be a danger of wind damage when heavy thinning becomes necessary. With a well grown uniform stand, the temptation to keep the trees is strong, but it should be firmly resisted.

Supplying cannot always be avoided, because tree losses due to damage by falling trees or lightning are often in groups. Control measures should prevent the loss of adjacent trees from root disease, which, moreover, will generally cause few losses until about the third year after planting, by which time supplying is rarely effective. The choice of initial density should therefore take into account the root disease history of the field. Allowance should also be made for losses due to falling timber, where the old stand is being cleared by poisoning the standing trees.

The last word on this problem still cannot be said. All our correspondents appreciate the value of a planned thinning programme. Considerable latitude is allowable in implementing it.— Editor.

R. R. I. News

Mr R.J. Garner, N.D.H., D.H.S., M.Sc (Hort), of the Pomology Division of East Malling Research Station, is being seconded to our Botanical Division for about four months to work on the vegetative propagation of rubber. The aim is to produce clonal rootstocks and self-rooting cuttings. The importance of this line of investigation was emphasised by the Blackman Committee. Mr Garner, author of 'The Grafters' Handbook', is an acknowledged expert in the field of vegetative reproduction of trees. He will be working at the R.R.I. Experiment Station, Sungei Buloh.

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Dr F.W. Shipley, of the British Rubber Producers' Research Association, is expected to arrive in Malaya at the end of July, to work at the R.R.I. for about two years. Dr Shipley, who is a Chemist, will be engaged in work on latex technology ranging from research on latex preservation to the preparation of foam rubber. This secondment exemplifies the closer cooperation which has been established between our Chemical Division and the B.R.P.R.A., the importance of which was stressed in the report of the Blackman Committee.

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